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Increasing the Metabolic Stress of an Unweighted Knee Exercise via Blood-flow Restriction Training: A Potential Treatment Adjunct for Physiotherapists.

Authors

Mr Philip J Smith¹, Dr May Azzawi¹, Mr Ben Stirling², Dr Rachel Stockley¹, Dr Peter C Goodwin¹

¹ *Manchester Metropolitan University, Manchester, United Kingdom*

² *Warrington Wolves Rugby League Club, Warrington, United Kingdom*

Background: Blood-flow Restriction Training [BfRT] involves the temporary, artificial reduction of blood flow through a limb, often during low-intensity resistance exercise. Following lower-limb injury or surgery, evidence suggests that BfRT can be used to minimise losses in thigh muscle size and strength or accelerate their return. However, the restriction equipment used in BfRT research is often inaccessible to frontline clinicians. There is also little evidence as to the acute metabolic effect of adding blood-flow restriction to un-resisted, or 'no load', rehabilitation exercises.

Purpose: Using an inexpensive restriction device, this study investigated whether adding lower-limb blood-flow restriction to a rehabilitation-appropriate 'no load' knee exercise produced a significant change in the acute metabolic stress of the exercise session.

Methods: The height, weight and leg measurements of n=16 healthy participants (n=9 male) were recorded. Participants attended four exercise sessions separated by at least 48 hours. Each session consisted of three, one-minute sets of a single-leg, unweighted knee-extension exercise. Throughout all sessions a 21cm-wide thigh blood-pressure cuff was wrapped around the thigh of the exercising limb. During the first exercise session the cuff was not inflated [control]. Over the remaining three sessions, the cuff was inflated to one preselected pressure [40/60/80mmHg] in order to restrict blood flow through the exercising limb. At the start of these sessions, the percentage of popliteal arterial blood-flow volume remaining after cuff inflation [BfR] was determined using Doppler ultrasound. To indicate metabolic stress, near infra-red spectroscopy was used to record deoxygenated haemoglobin mass [HHb] of the vastus lateralis muscle before and during every exercise session. Cohort differences in BfR and HHb change for each exercise session were then compared.

Results: All participants completed all exercise sessions. BfR decreased as cuff pressure was increased, with 80mmHg inducing a mean BfR of 47.6% (95% CI 42.9% - 52.3%). HHb of the vastus lateralis muscle did not increase during the control session. HHb of the vastus lateralis muscle increased significantly when cuff pressures were applied during the three remaining sessions. (Repeated Measures ANOVA, $p < 0.001$, partial η^2 0.65). Overall, a higher Body Mass Index was associated with smaller changes in HHb of the vastus lateralis muscle during sessions in which cuff pressures were applied (Pearson $R = -0.794$, R^2 0.630, $p < 0.001$).

Conclusions: Results indicate that adding lower-limb blood-flow restriction significantly increased the local, acute metabolic stress of a rehabilitation-appropriate knee exercise without the need to increase exercise load or repetitions. At cuff pressures up to 80mmHg, the degree of metabolic stress experienced during 'no load' BfRT differed between individuals and was associated with their Body Mass Index.

Implications: Using an inexpensive blood-pressure cuff as the restriction device, findings support the potential use of lower-limb BfRT as a treatment adjunct following lower-limb injury. To deliver a consistent level of metabolic stress among different individuals, clinicians may need to tailor the amount of thigh cuff pressure that they apply based upon an individual's physical size. Further research is required to determine the potential magnitude of acute metabolic stress required to attenuate the effects of muscle disuse within injured populations.

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